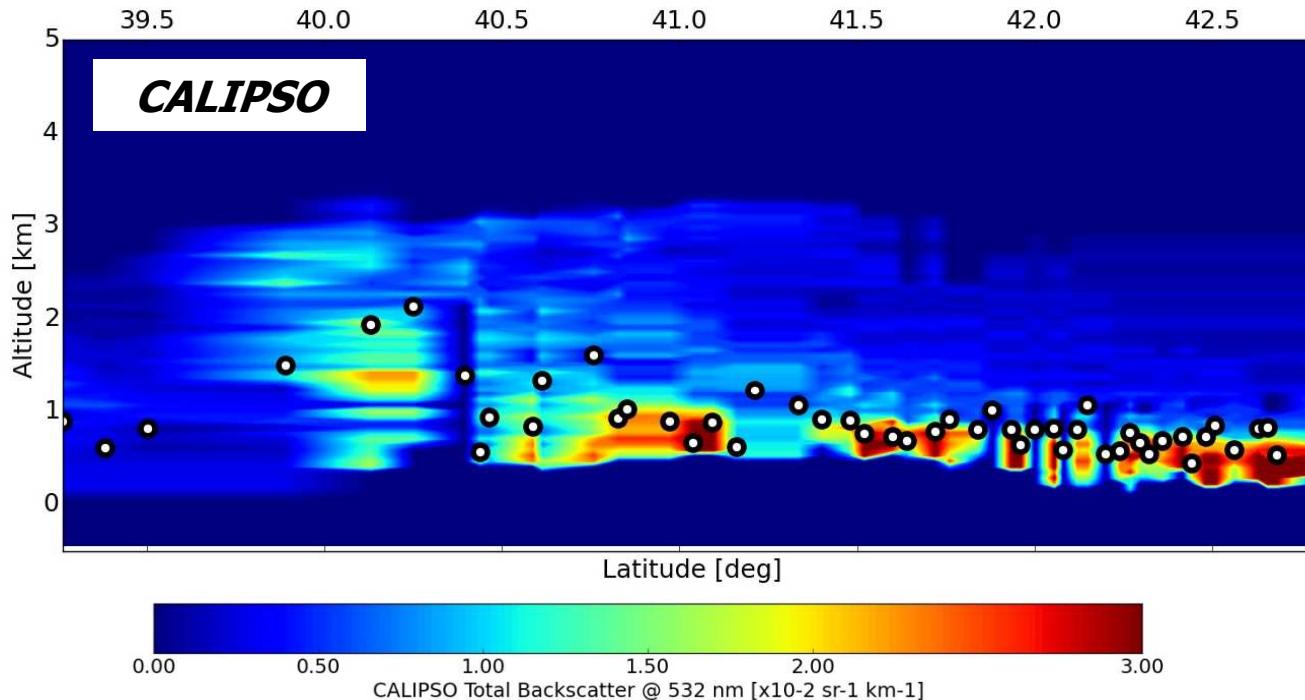


Aerosol retrievals from the OMI 477 nm O₂-O₂ band – Polluted & *cloud-free* scenes over North-East Asia

Aerosol height: a new OMI(-MODIS) product?



○ =  **OMI**
Aerosol height

Julien Chimot, Pepijn Veefkind, Tim Vlemmix, Pieterernel Levelt

NASA EOS Aura Meeting, Rotterdam – 2016.08.31

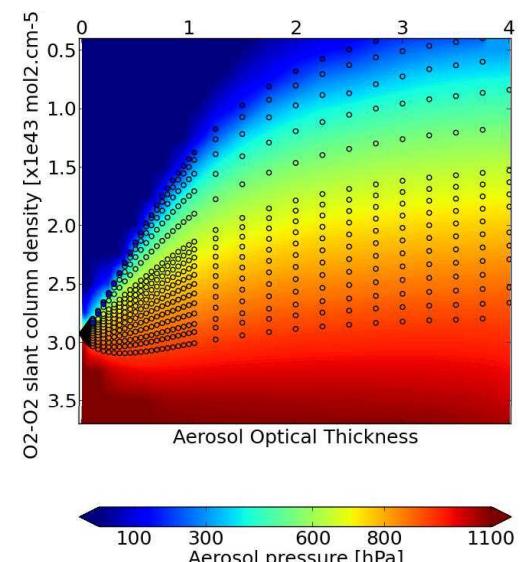
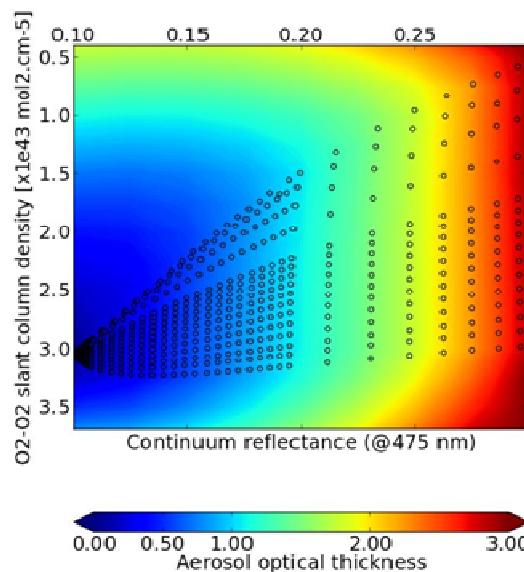
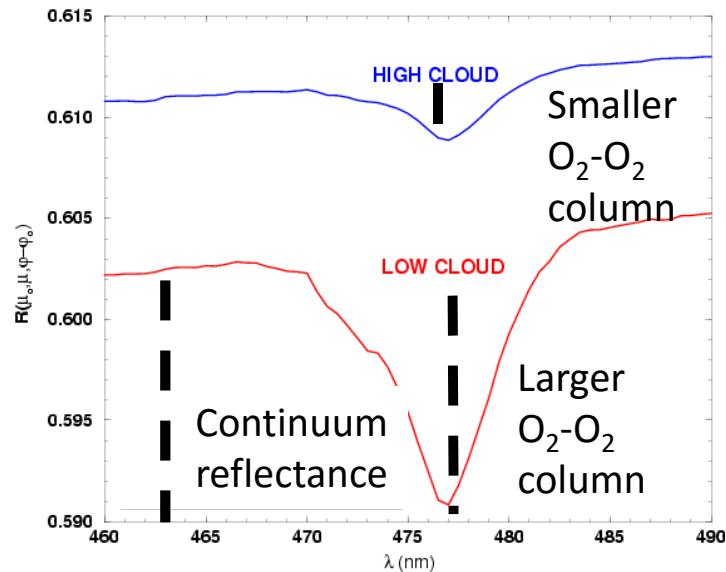
Outline

Development of neural network algorithm to derive aerosol height from the OMI 477 nm O₂-O₂ band: what are its capabilities?

- **Aerosols and the OMI 477 nm O₂-O₂ band**
- **Illustrative case study (recent work)**
 - *Collocated OMI, MODIS & CALIPSO, North East Asia, 4 days October 2006*
- **Statistic evaluation: 3-year observations (2005-2007)**
 - *Focus over land, North-East Asia*
- **Conclusion & Outlook**

Aerosols and the OMI 477 nm O₂-O₂ band

O₂-O₂ @477 nm: Aerosol properties implicitly captured by the (effective) OMI clouds (OMCLDO2)... [Chimot *et al.*, 2016]



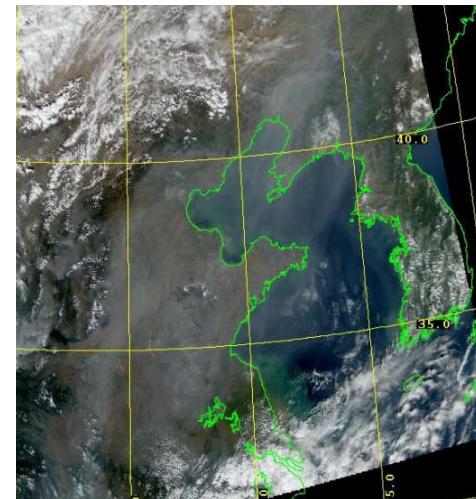
- Aerosol scattering efficiency enhances the scene brightness (*cf.* continuum reflectance)
- Shielding of the layers located below aerosol layers (*cf.* O₂-O₂ slant column)
- Aerosol height retrieval requires a reliable AOT information

Illustrative case study (recent work)

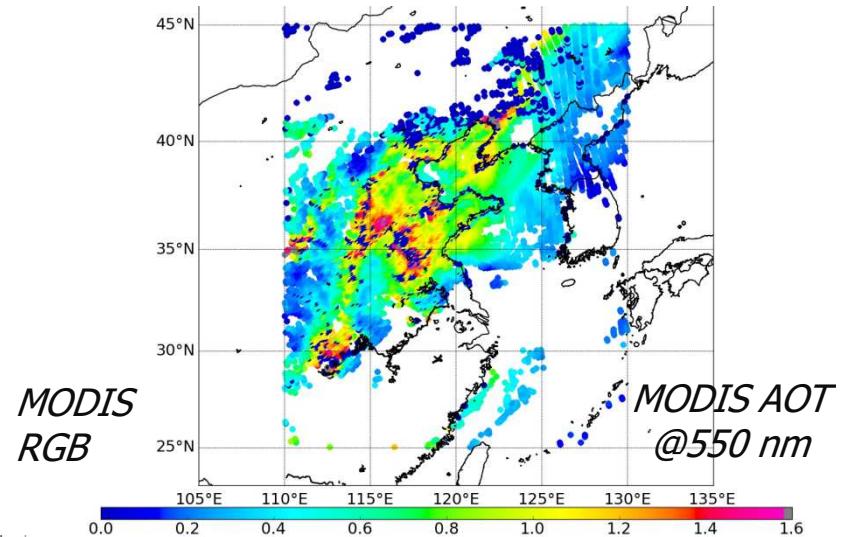
2006.10.02: 7 days of strong pollution over North-East China

Different factors:

- Cold air
- Burning agricultural wastes after harvesting
- Increased emissions from coal-burning power plants

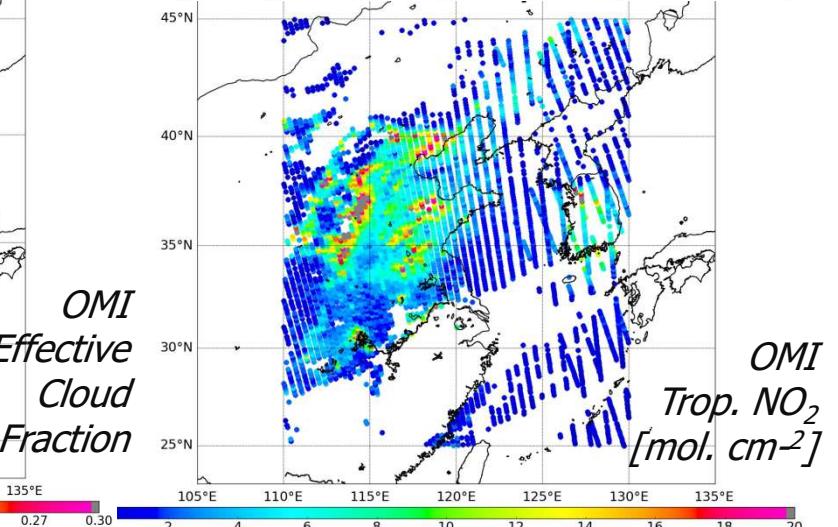
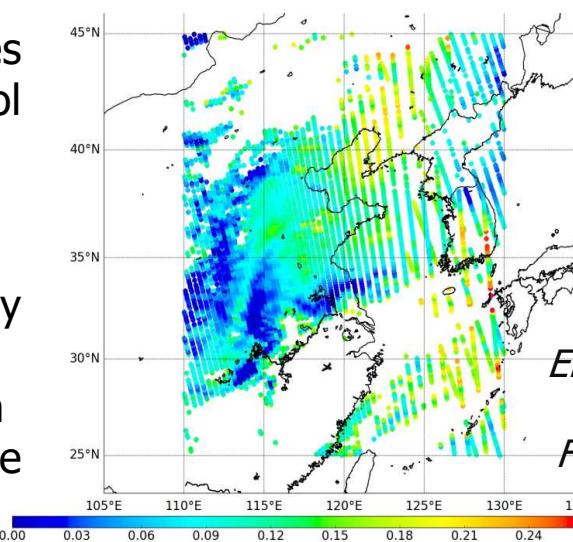


MODIS-Aqua observes strong aerosol pollution ($AOT > 1.0$)

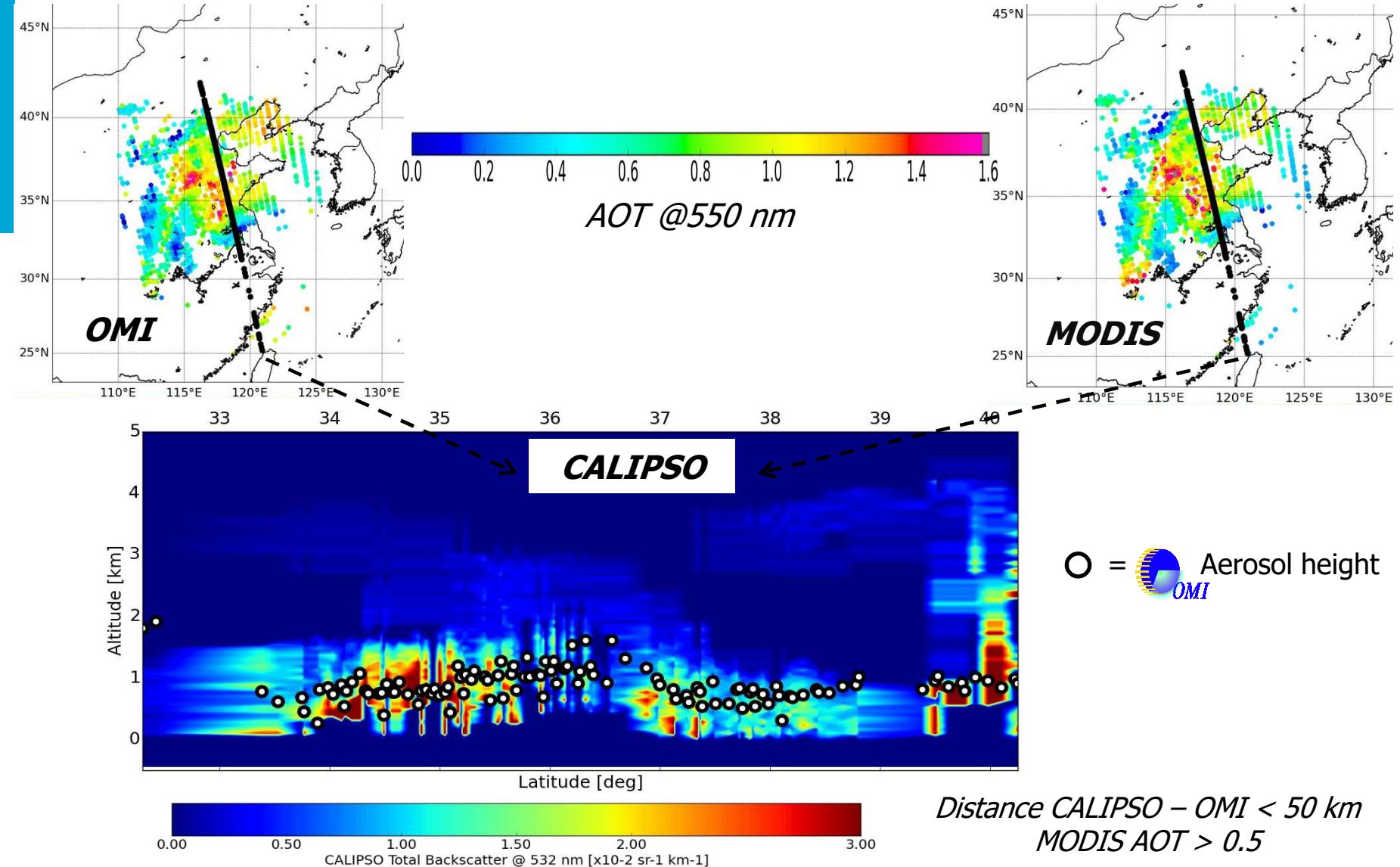


OMI simultaneously observes:

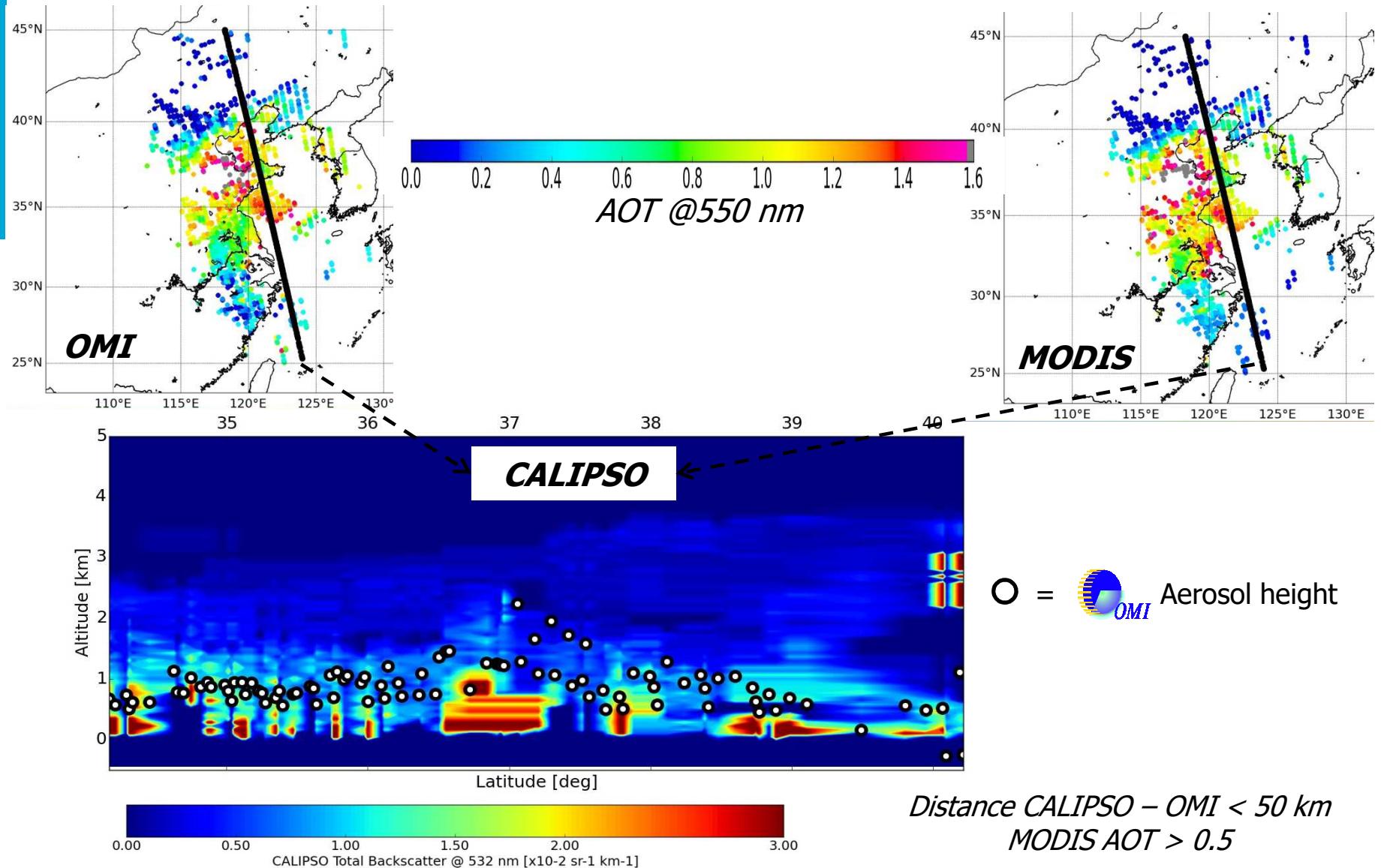
- Strong NO_2 pollution
- Enhanced scene brightness



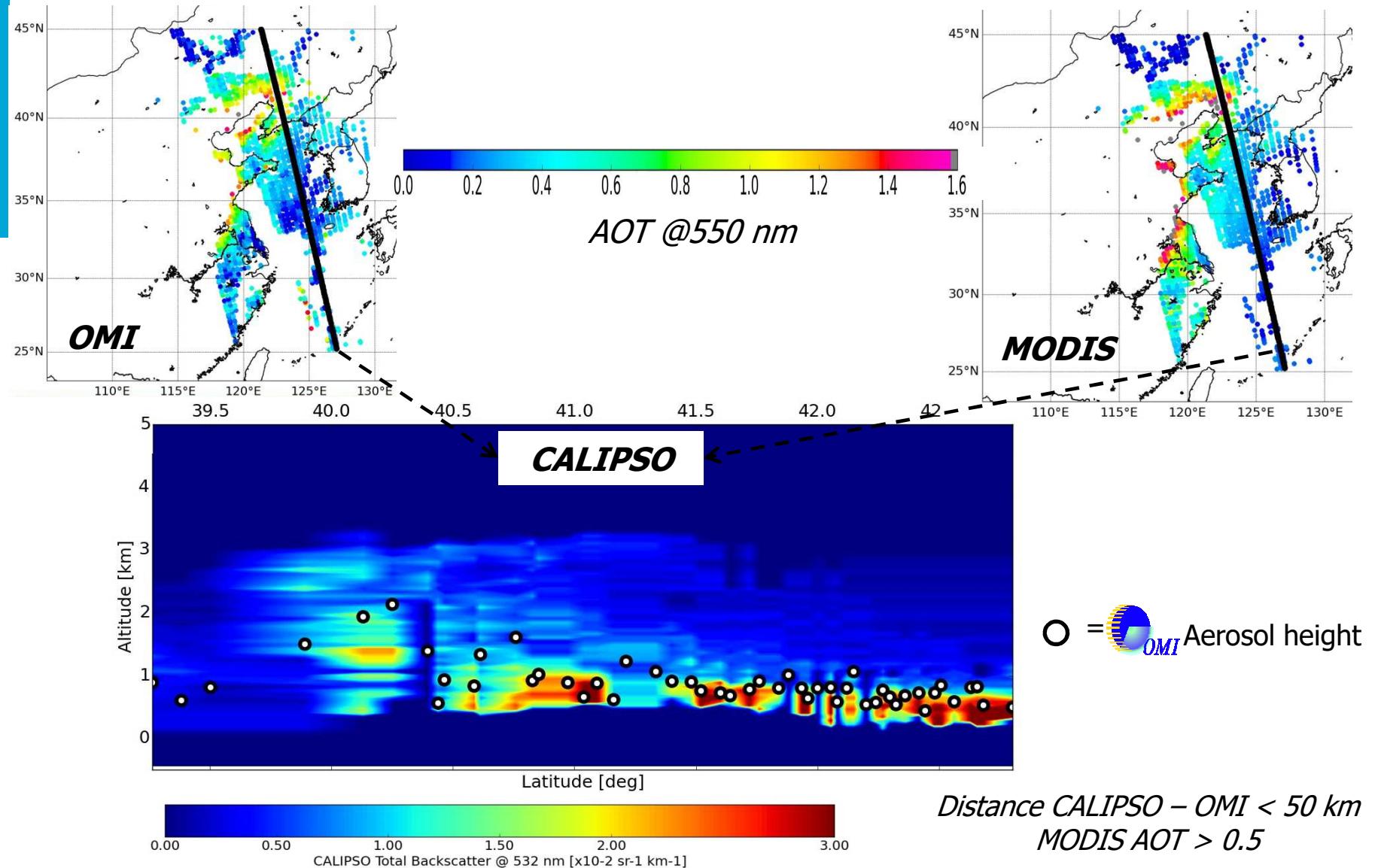
2006.10.02: Collocated OMI, MODIS & CALIPSO aerosols



2006.10.04: Collocated OMI, MODIS & CALIPSO aerosols



2006.10.06: Collocated OMI, MODIS & CALIPSO aerosols



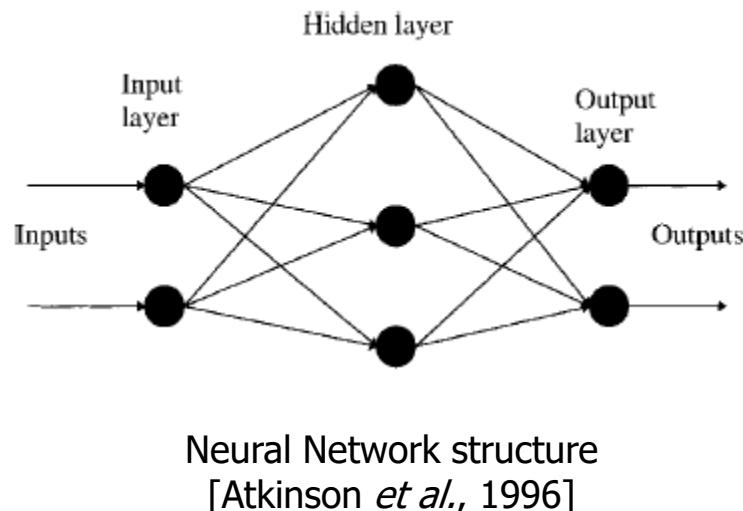
Statistic evaluation: 3-year **cloud-free** observations (2005-2007)

Idea

Optimized interpolation technique and ability to deal with **non-linear** problems

A 2-step approach:

- 1) DOAS analysis over 460-490 nm: continuum reflectance (Rc) and O₂-O₂ Slant Column Density (SCD)
- 2) Neural Network (NN) conversion => AOT & Aerosol height [hPa]



Details for Neural Networks experts

- PyBrain Machine Learning [Schaul *et al.*, 2010] - Based on MultiLayer Perceptron techniques [Rumelhart *et al.*, 1986]
- Large supervision dataset ($\sim 200\ 000$ simulations) x 2 aerosol models (SSA 0.95 & 0.9)
- Back-propagation technique to minimize a cost function - ~ 500 iterations per NN design
- Sigmoid functions in the hidden layers
- Supervision dataset randomly divided into 3 categories: training (70%), validation (15% - convergence) & test (15% - final score) => selection of the best NN

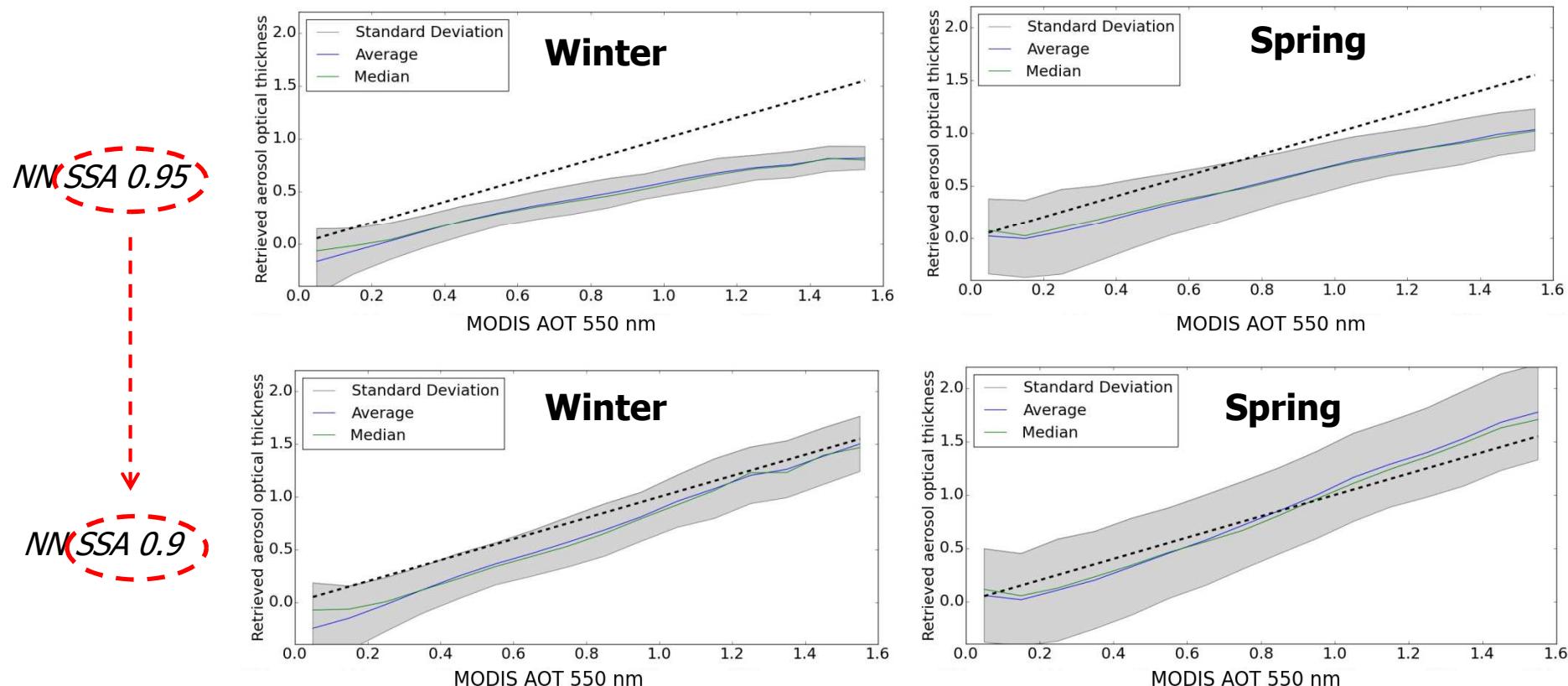
Statistic evaluation: 3-year ***cloud-free*** observations (2005-2007)

Can we derive AOT from the OMI 477 nm O₂-O₂ band?

OMI AOT retrievals are sensitive to the choice of the aerosol model

Overall good agreement for SSA = 0.9: -0.21 ± 0.24 (Winter) -0.02 ± 0.45 (Spring)

Collocated OMI-MODIS 2005-2007, East-China, cloud-free scenes



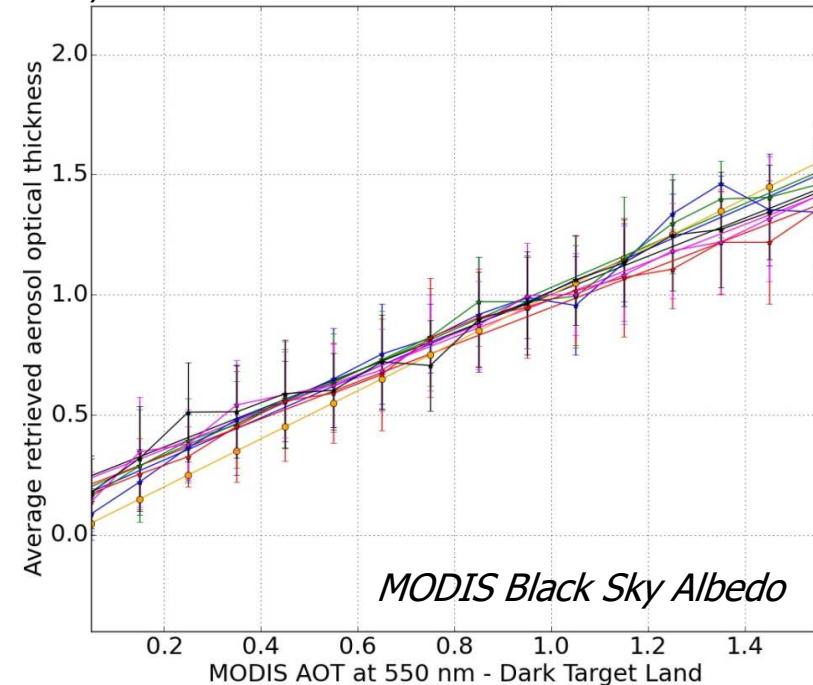
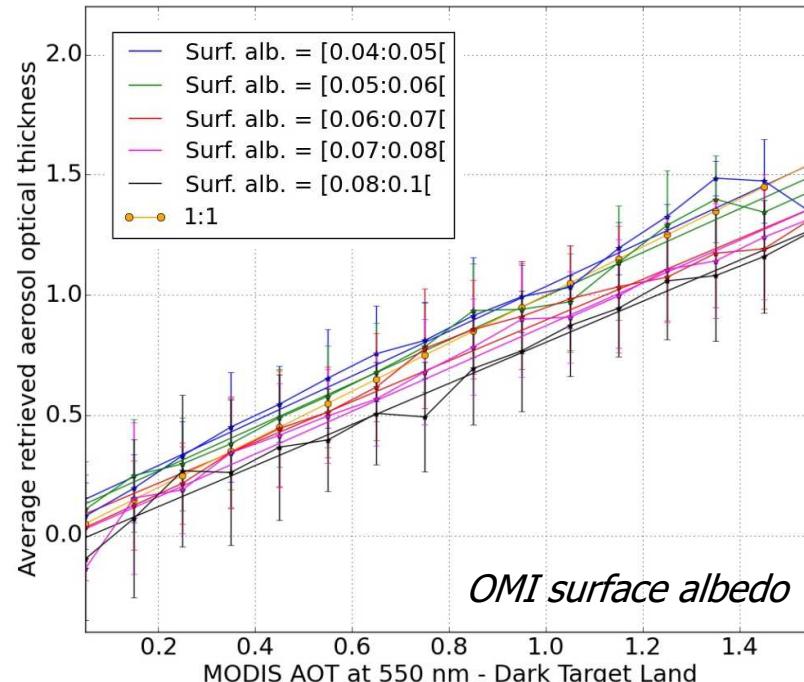
Statistic evaluation: 3-year *cloud-free* observations (2005-2007)

A look on OMI AOT retrievals...

Reduction of the OMI AOT spread when the input surface albedo is optimized:

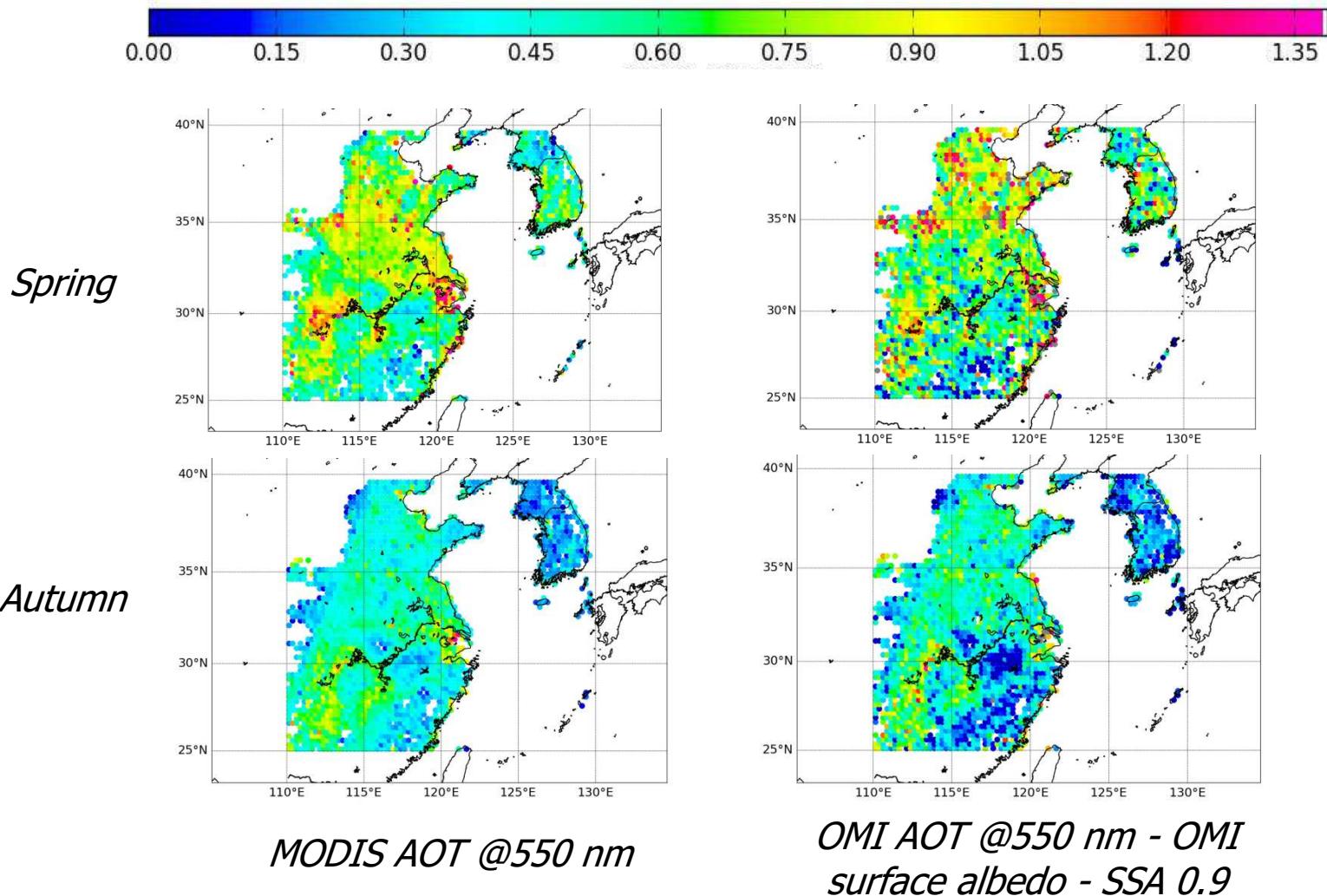
- OMLER [Kleipool *et al.*, 2008], surface reflectance climatology, 0.5 deg \times 0.5 deg, potential residual aerosols
- MODIS black sky albedo: daily 16-day, directional hemispherical reflectance, 5600 m resolution, integrated atmospherically corrected BRDF [Schaaf *et al.*, 1999, 2002]

10.2006, 02-09, North-East China, cloud-free scenes



Statistic evaluation: 3-year *cloud-free* observations (2005-2007)

A look on OMI AOT retrievals (2005-2007, cloud-free scenes, China)...



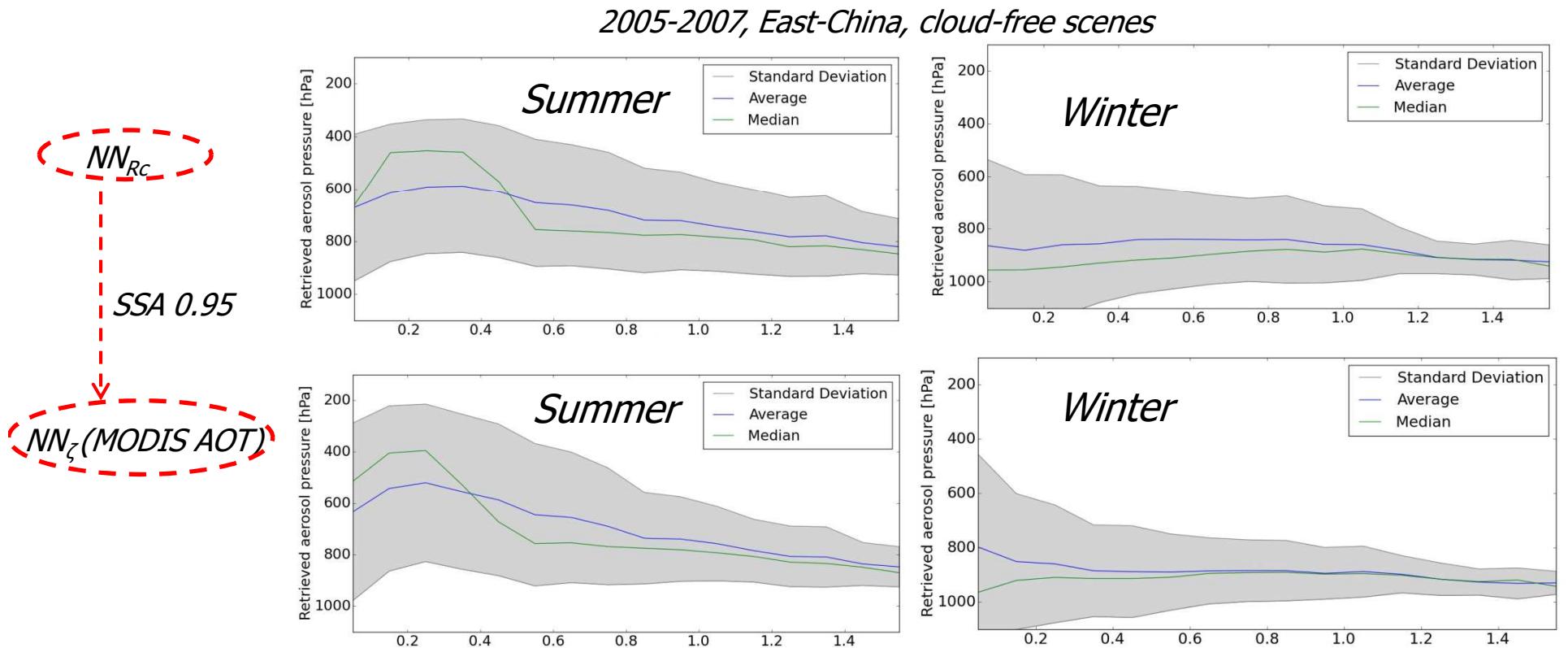
Statistic evaluation: 3-year *cloud-free* observations (2005-2007)

A look on OMI aerosol height retrievals...

For AOT < 0.5: Large biases expected on retrieved aerosol height

For AOT > 0.5:

- ✓ Reduced variability with MODIS AOT as input instead of continuum reflectance 475 nm
- ✓ Temperature correction on O₂-O₂ SCD requested [Veefkind *et al.*, 2016]

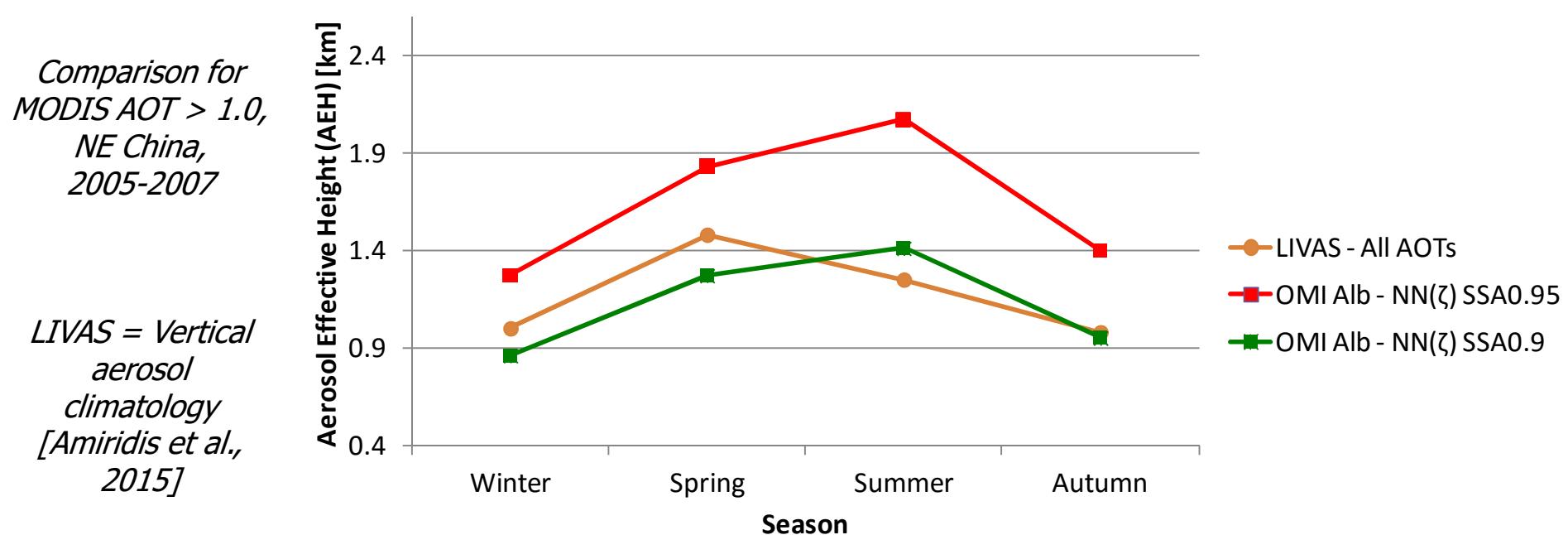


Statistic evaluation: 3-year *cloud-free* observations (2005-2007)

A look on OMI aerosol height retrievals...

Based on continuum reflectance (NN_{Rc}): Strong sensitivity to the choice of the aerosol model (1 km)

Based on MODIS AOT (NN_ζ): AEH biases (max 500 m) & reduced sensitivity to the assumed aerosol model



Conclusion: OMI aerosol height **Over cloud-free scenes**

- Towards a more complete tropospheric pollution overview from simultaneous OMI measurements: NO₂, AOT & SSA from the UV (*cf.* OMAERUV), AOT and aerosol height from the 477 nm O₂-O₂ band
- Capabilities of Neural Network algorithms to retrieve aerosol height from the O₂-O₂ 477 nm?
 - Requires a reliable AOT information: strong benefits of instruments synergy (OMI-MODIS) + evaluation with collocated CALIPSO
 - Retrieval of aerosol heights from the O₂-O₂ SCD, & for AOTs @550 nm > 0.8:
 - Biases about 500 m over NE China (statistics over 3 years 2005-2007)
 - In addition, retrieval of OMI AOT from the continuum reflectance @ 475 nm:
 - Strong sensitivity to the assumed SSA & surface albedo
- O₂-O₂ @477 nm: a new alternative to other O₂-O₂ (UV) or O₂-A - Comparison or combination?
- What could be done with the OMI aerosol height?
 - Climate and air quality research
 - Feasibility of explicit aerosol correction on the OMI tropospheric NO₂ retrievals to be investigated

Julien Chimot MSc | Dr. Tim Vlemmix | Prof. dr. Pepijn Veefkind |
Prof. dr. Pieter Nel Levelt

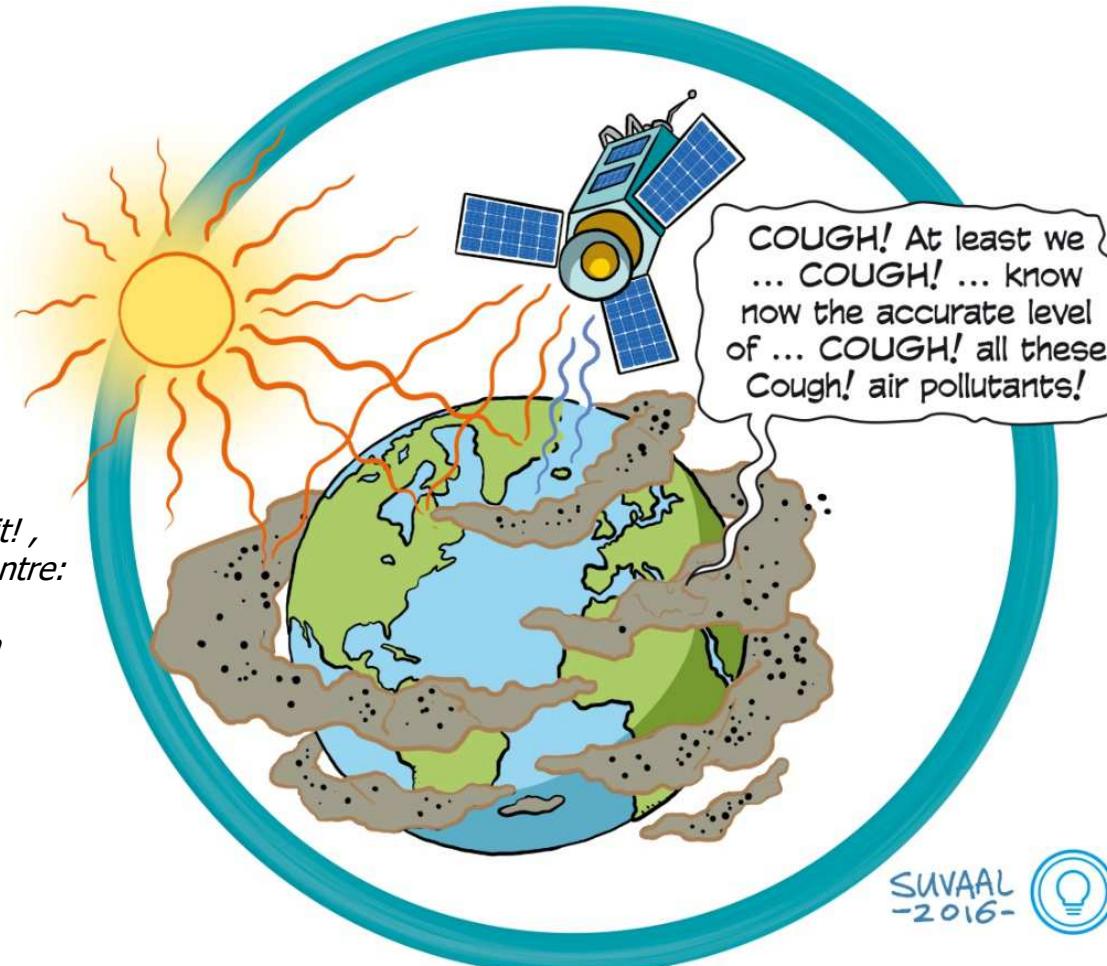


Designer team of DIG-it!,
TU Delft / Valorisation centre:

Dorien van Alphen

Robbert van Leeuwen

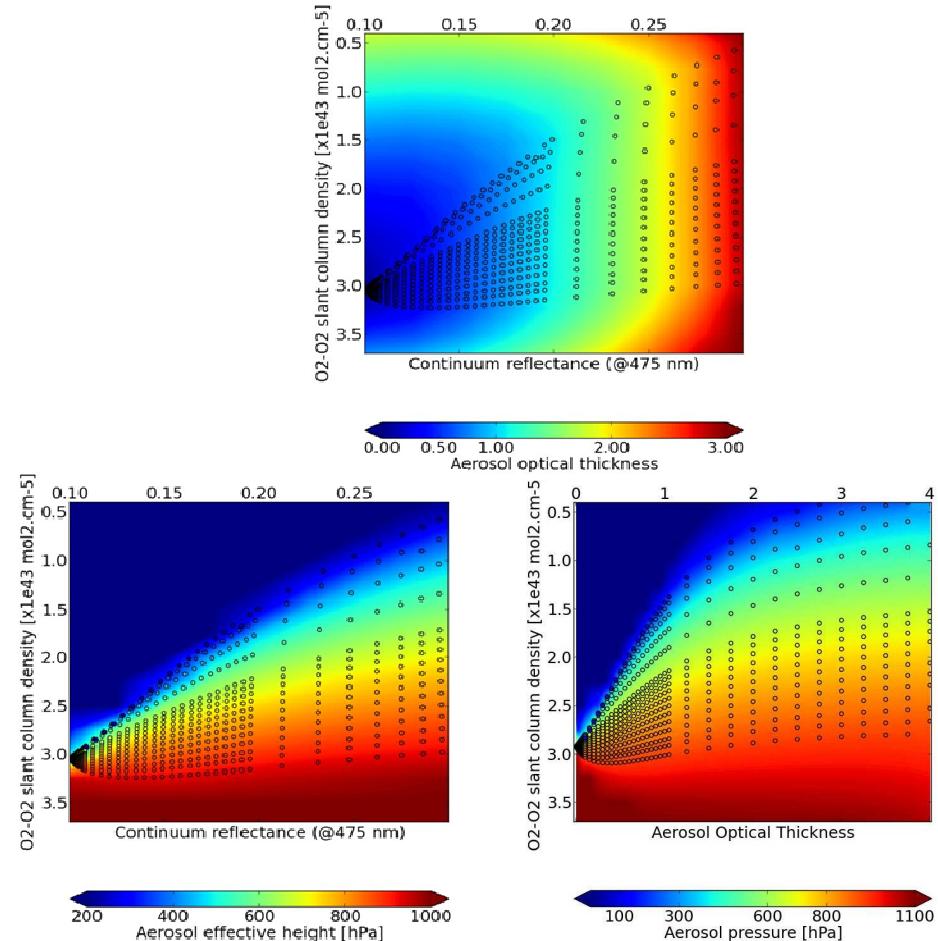
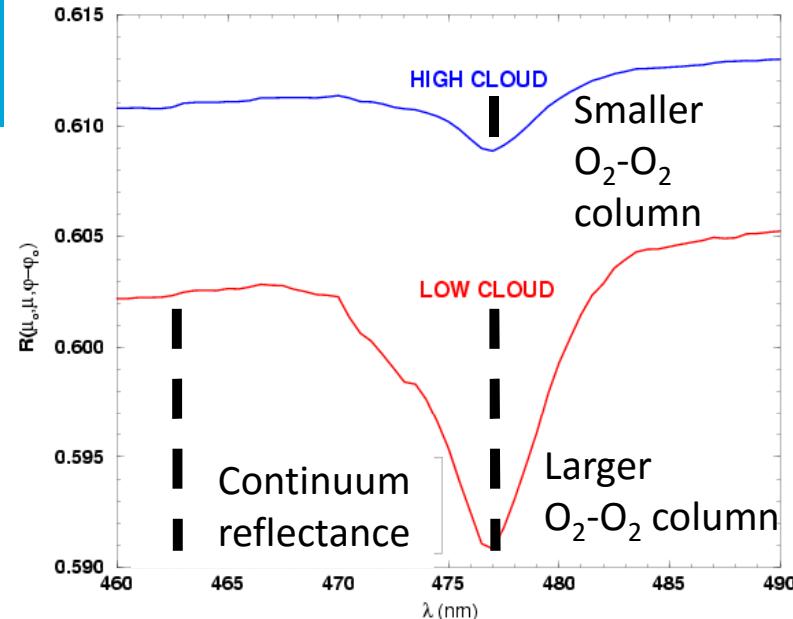
Susanne Sleenhoff



Thank you for your attention!

Motivation & description

O2-O2 @477 nm: a band, impacted by aerosols, but exploited for (effective) cloud retrievals (OMCLDO2)...



2006.10.09: Collocated OMI, MODIS & CALIPSO aerosols

